ISTITUTO NAZIONALE
DI GEOFISICA E VULCANOLOGIA

MARsite

Marsite Project
final report of INGV activities for WP2, Task2.1

April 2015

PS processing of COSMO-SkyMed data for crustal deformation analysis in the Istanbul area

A. Nobile, J.P. Merryman Boncori, S. Salvi
Istituto Nazionale di Geofisica e Vulcanologia - Rome, Italy

Cite as: Nobile, A., Merryman Boncori, J., P., Salvi, S., 2015, PS processing of COSMO-SkyMed data for crustal deformation analysis in the Istanbul area. Final report for the FP7 MARSITE project, DOI 10.5281/zenodo.1045869

In order to investigate crustal deformation in the Istanbul area, we analyzed COSMO-SkyMed SAR images from two different ascending tracks (Fig. 1). The data were made available from the Italian Space Agency to the Marmara Supersite.

Data and method

For the easternmost track (hereafter East Track) we processed 30 image strips consisting of two standard COSMO-SkyMed frames each, covering the period between 5 June 2011 and 30 September 2013.

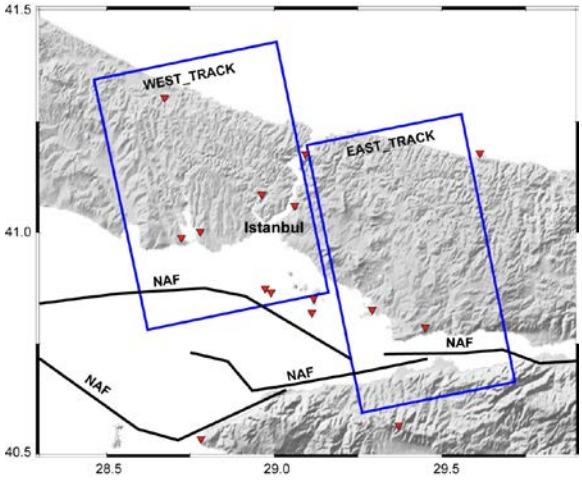


Fig. 1 Blue rectangles show the area covered by the two COSMO-Skymed ascending tracks used in this study. Black lines are the North Anatolian Fault (NAF) segments. Red triangles are the GPS stations in the area provided by KOERI.

For the westernmost track (hereafter West Track) we processed 68 frames covering the period between 24 May 2011 and 16 July 2013.
The temporal distributions of the image acquisitions for both tracks are shown in Figure 2 and, with respect to the perpendicular baseline to the master image, in Figures 3 and 4.
We processed the data using the StaMPS method [Hooper et al., 2007]. Using the DORIS software (http://doris.tudelft.nl), run through StaMPS processing scripts, we generated 28 interferograms related to a master image acquired on 07 June 2012, for Track East, while for the West Track we generated 63 interferograms with respect to a master acquisition on 08 April 2012.
In order to subtract the interferograms phase component due to topography we used a Digital Elevation Model obtained by the SRTM-3 mission. We also tested the cartographic 5m DEM provided by the Marsite Project and an ASTER 30 m DEM. As shown in Fig. 5 the first one covers just part of the study area and did not provide evident improvements on the coherence respect to the SRTM. Using the ASTER DEM we obtained a degraded interferometric coherence.

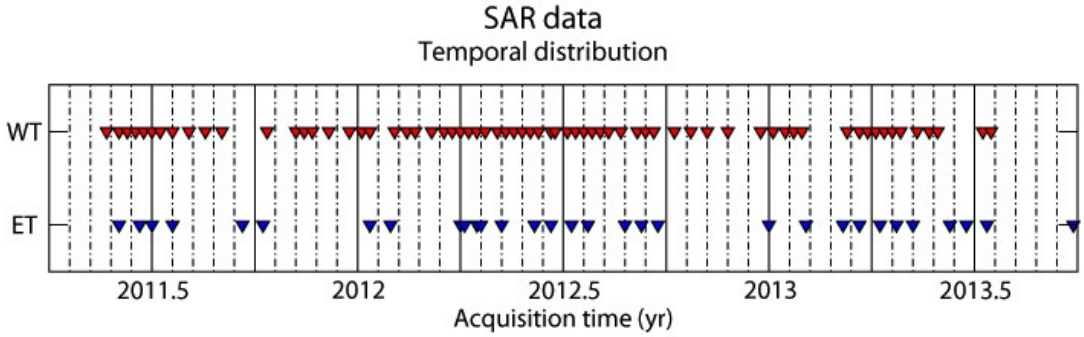


Fig. 2 Temporal distribution of COSMO-SkyMed acquisitions over Istanbul, for the two tracks: WT: West track, ET: East track. The vertical dotted lines are spaced 15 days apart.

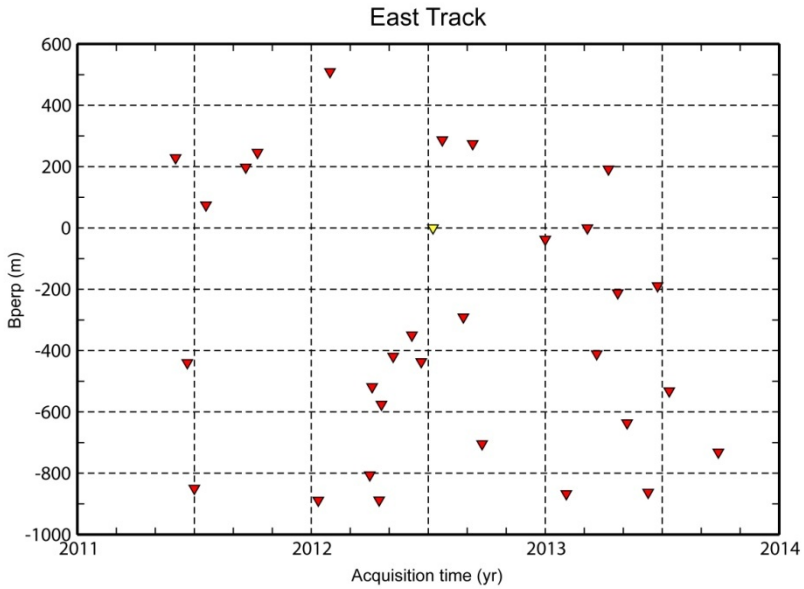


Fig. 3 Acquisition date vs perpendicular baseline for the 30 images of the East Track. The yellow triangle in the center is the master image (2012-06-07) used to calculate the interferograms.

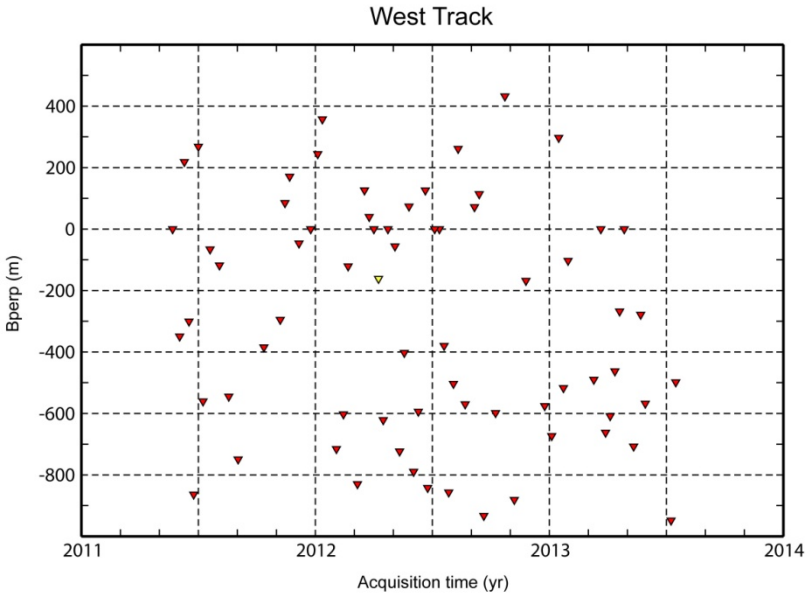


Fig. 4 Acquisition date vs perpendicular baseline for the 68 images of the West Track. The yellow triangle near the center is the master image (2012-08-08) used to calculate the interferograms.

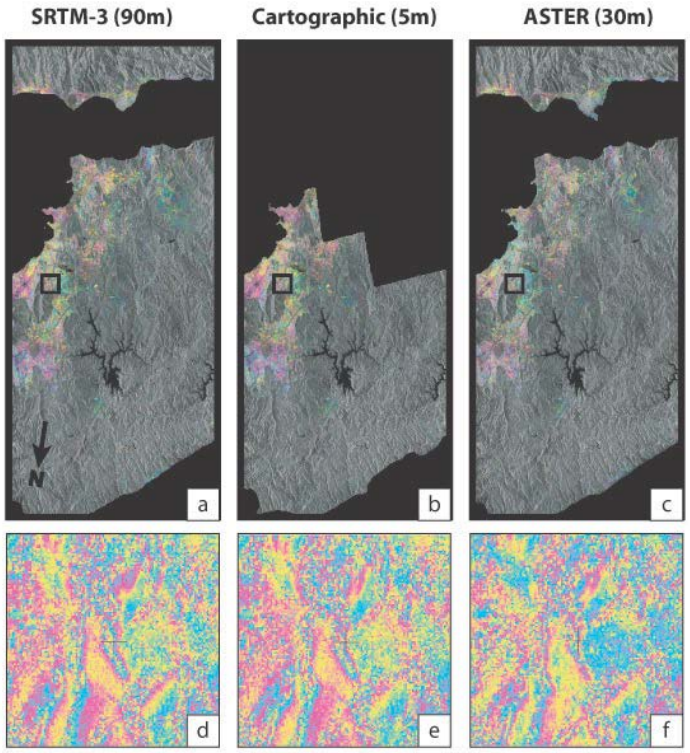


Fig. 5 Comparison between the same interferogram (20120404-20120607 – East Track - ~200m perpendicular baseline) produced with GAMMA Software and corrected with different DEMs. a) SRTM-3 DEM (90m), b) Cartographic DEM (5m) provided by the Marsite project, c) ASTER DEM (30m). Images are in radar geometry. Black squares corresponds to d), e) and f) images respectively. Between d) and e) there are no evident coherence improvements, however the Cartographic DEM covers only part of east track. Using the ASTER DEM we did not improve the final result.

Results

In Fig. 6 we show the final mean velocity map for the East Track, and in Fig. 10 the velocity map for the West Track. The presence of mountains and vegetation strongly limits the number of coherent pixels in non-urban areas. Each ground velocity map is referred to a reference point showing a stable behavior during the analyzed period. In the following we comment the results for the different tracks.

Results for the East Track

In this area the mean ground velocities (Fig. 6) vary between ±10 mm/yr; the time series in general show an approximately linear trend, other than where very local effects occur (Fig. 7, point B).

We carried out a qualitative validation comparing our results to those produced by Walters et al., 2010 using descending ERS-ENVISAT data. The descending velocities show diminishing values going from east to west along the Marmara coast SE of the Bosphorous (Fig. 6). The COSMO-SkyMed mean ascending velocities from the East Track show instead an opposite trend, with values increasing from east to west in the same area (Fig.8). This behavior suggests that the observed movements are mainly due to horizontal deformation occurring along the E-W direction.

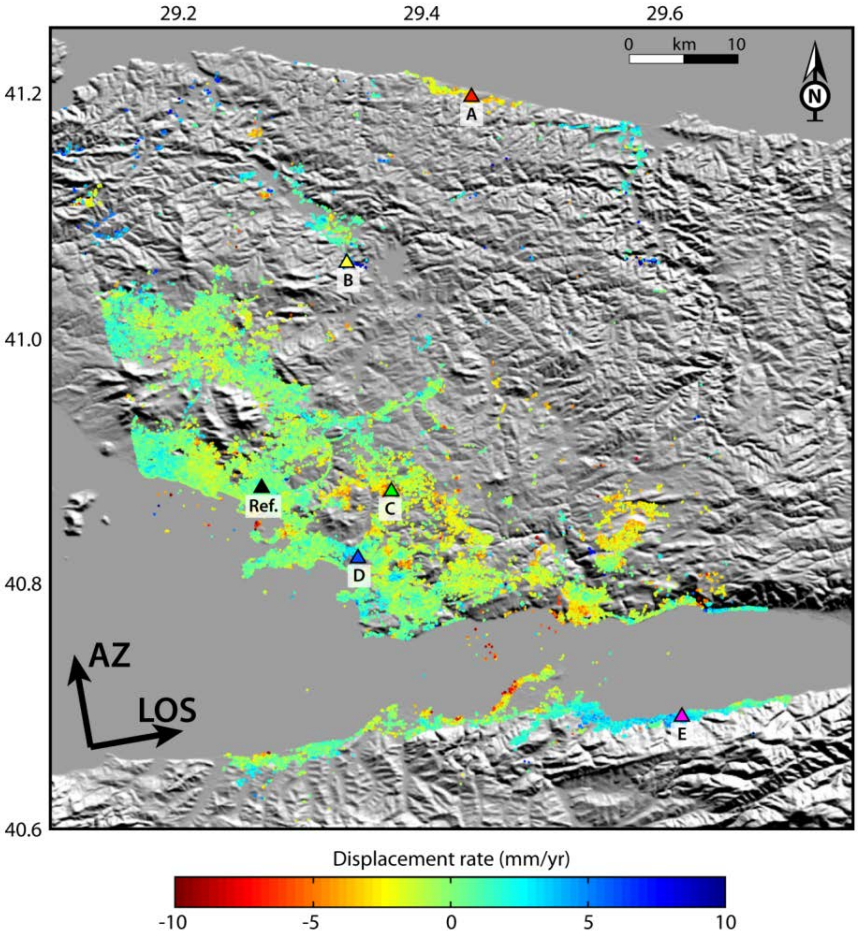


Fig. 6 Mean velocity map for the East Track. Colored triangles are the sites referred to in Fig. 7. Black triangle is the reference point for the mean velocities.

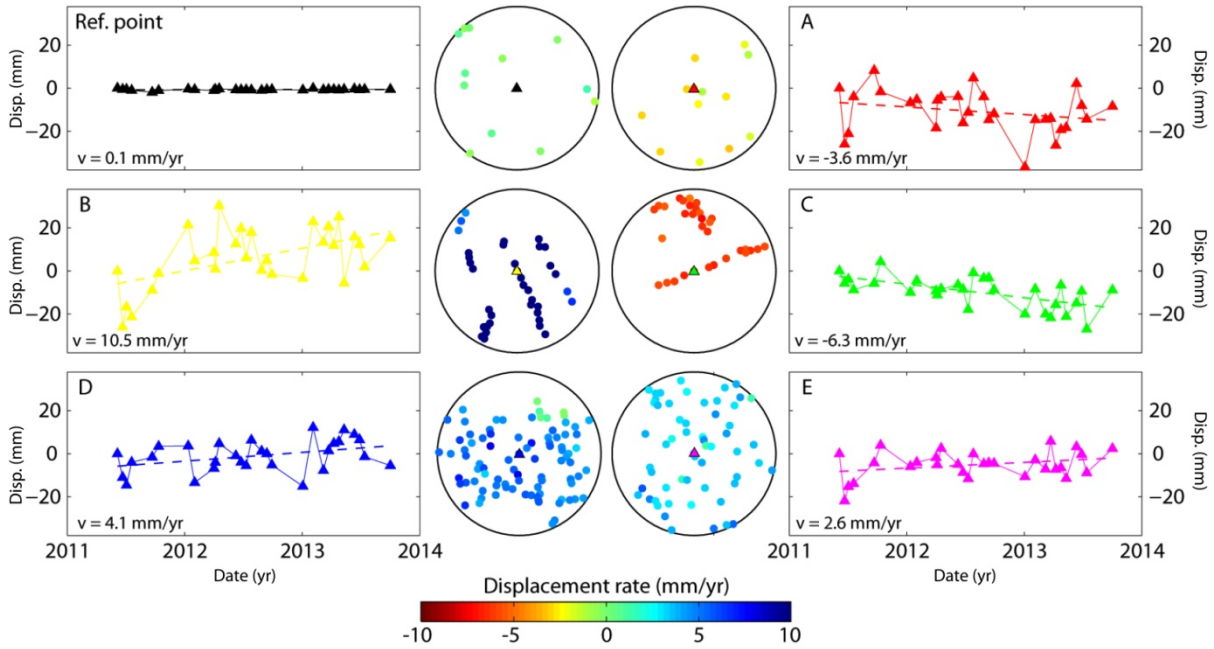


Fig. 7 Displacement time series for six points in the East Track. The graphs show the mean time series of all the pixels in the corresponding circle (100 m radius). The dashed lines indicate the linear fit from which the ground velocity is obtained. The top left graph shows the reference point time series.

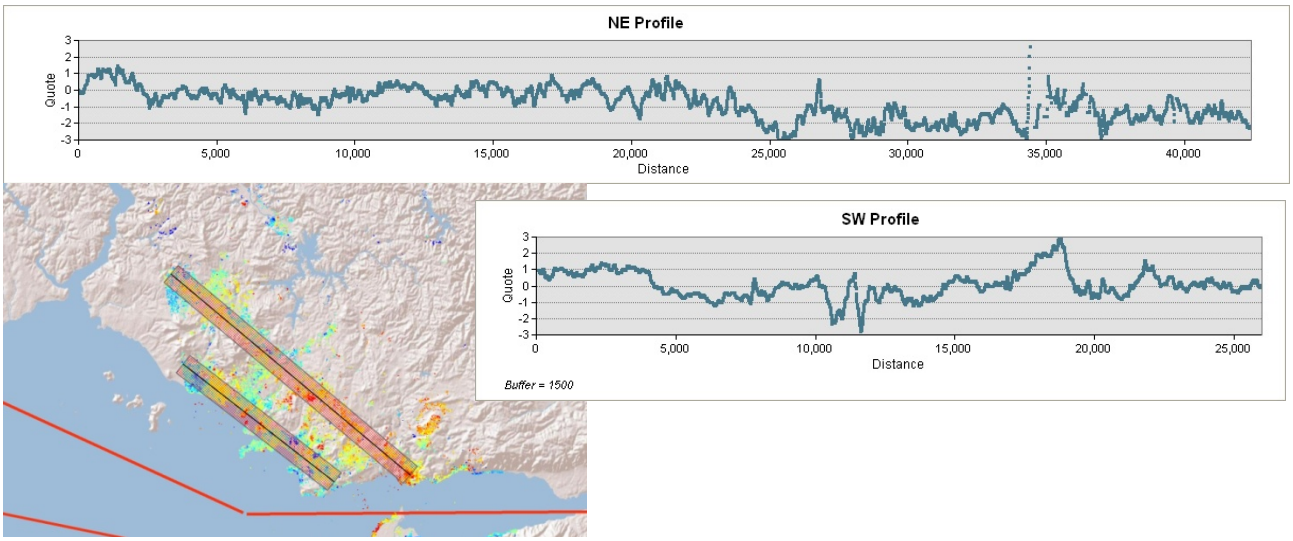


Fig. 8 - Velocity profiles along the NW-SE direction at two different locations (see map).

Results for the West Track

In this area the mean ground velocities vary between -20 and 10 mm/yr (Fig. 9); the time series are noisier than those for the East Track, but show in general a linear trend with small non linear components (Fig. 10).

There is no evident trend at long spatial wavelength, while many locally deformed areas are present. Most of them correspond to sites where Walters et al., 2010, find the same behaviour using descending data. This implies that the actual movement on the ground is mainly occurring along the vertical direction.

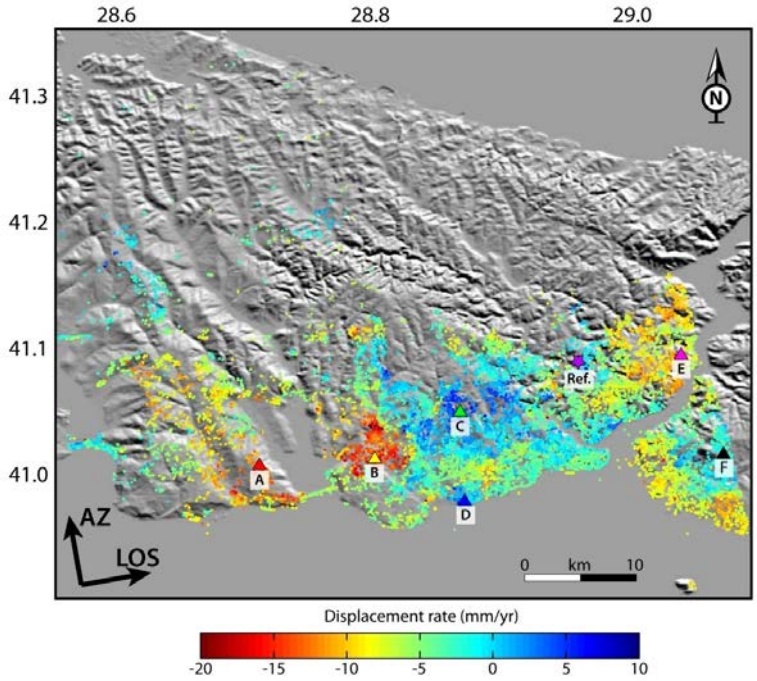


Fig. 9 Mean velocity map for the West Track. Colored triangles are the sites referred to in Fig. 10. The purple star is the reference point for the mean velocities.

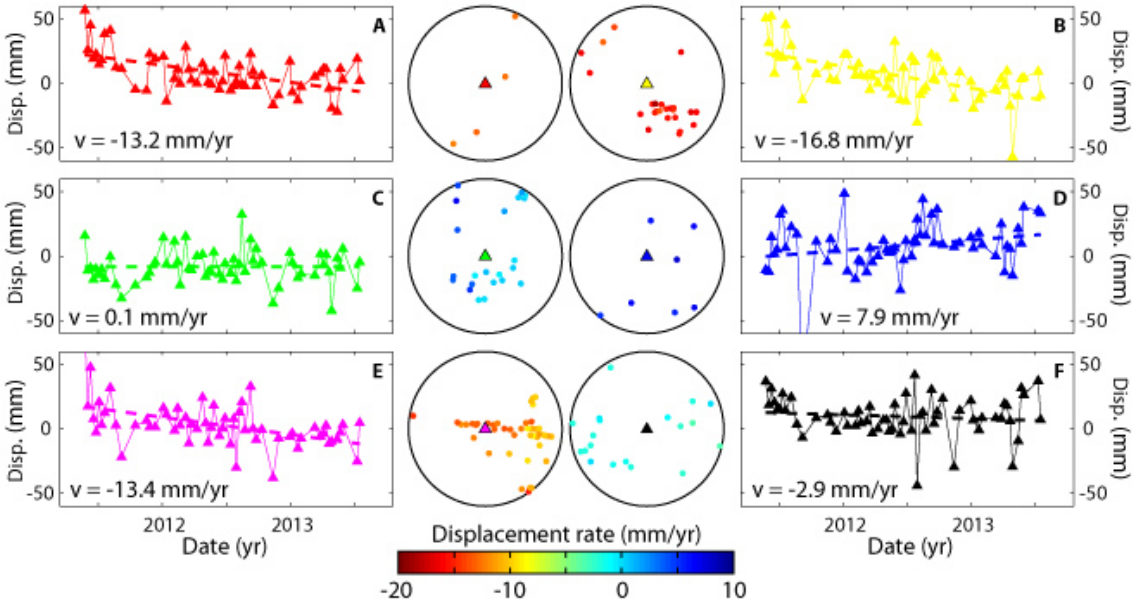
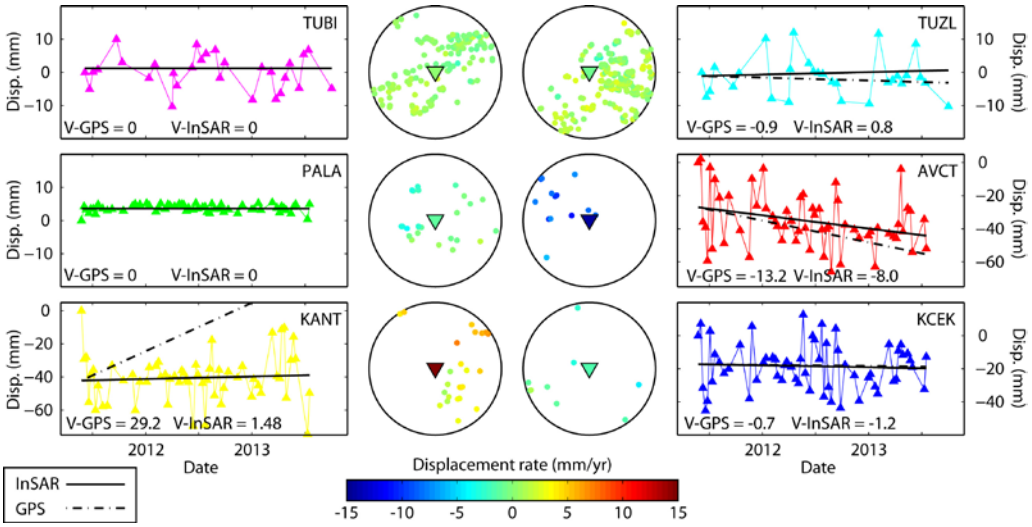


Fig. 10 Ground displacement time series for six points in the West Track. The graphs show the mean time series of all the pixels in the corresponding circle (200 m radius). The dashed lines indicate the linear fit from which the ground velocity is obtained. Some time series (e.g. point E) are still characterized by unwrapping artifacts.

We validated the InSAR results from the West Track with CGPS data: in the figure 11 the comparison between the available CGPS velocities and the overlapping InSAR velocities is shown.



The InSAR time series are averaged over all coherent pixels in an area of 1 km radius around the CGPS station. Other than for the KANT station, for which there is a very anomalous GPS velocity, the other comparisons are in good agreement.

References

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